

Claims

- [c1] A continuous method for substantially converting heavy hydrocarbons having normal boiling points above 538°C (1000°F) to hydrocarbons having normal boiling points below 538°C (1000°F), comprising:
 - (A) providing a feed mixture of the heavy hydrocarbons with solvating hydrocarbons comprising normal boiling points below 538°C (1000°F), at a weight ratio of the solvating hydrocarbons to the heavy hydrocarbons of at least 2:1;
 - (B) introducing the feed mixture into a reaction zone containing hot particulate solids to form a reaction mixture;
 - (C) maintaining the reaction mixture in the reaction zone at a temperature and pressure above critical temperature and pressure of the feed mixture for a period of 60 seconds or less to deposit coke onto the solids and produce a first effluent stream comprising a suspension of the particulate solids in a mixture of solvating hydrocarbons including converted hydrocarbons having normal boiling points below 538°C (1000°F); and
 - (D) separating particulate solids from the first efflu-

ent stream to produce a solids-lean second effluent stream.

[c2] The method of claim 1 further comprising:

- (E) partially condensing the second effluent stream to form a third effluent stream essentially free of solids and lean in hydrocarbons boiling above 538°C (1000°F) and a fourth effluent stream comprising a slurry mixture of liquid hydrocarbons and solids;
- (F) separating the third effluent stream into solvent and one or more product streams, wherein the solvent stream comprises hydrocarbons with normal boiling points between 32° and 538°C (90° and 1000°F), a mixture of hydrocarbons selected from light naphthas comprising hydrocarbons with normal boiling points between 32° and 82°C (90° and 180°F), heavy naphthas comprising hydrocarbons with normal boiling points within the range of from 82°C to 221°C (180° to 430°F), distillates with normal boiling between 221° and 343°C (430°F and 650°F), gas oils with normal boiling points between 343° and 538°C (650°and 1000°F), and mixtures thereof, and the one or more product streams comprise converted hydrocarbons having normal boiling points below 538°C (1000°F); and
- (G) recycling at least a portion of the solvent as the

solvating hydrocarbons in the feed mixture to the reaction zone.

- [c3] The method of claim 2, further comprising recycling at least a portion of the slurry mixture from (E) to the reaction zone.
- [c4] The method of claim 2, further comprising recycling at least a portion of the slurry mixture from (E) with solids from the first effluent stream separation to a regeneration zone, regenerating the solids to remove coke and form hot regenerated particulate solids, and recirculating the regenerated particulate solids to the reaction zone in (B).
- [c5] The method of claim 4, wherein the solids regeneration comprises combustion of the coke in the presence of an oxygen-containing gas.
- [c6] The method of claim 2, wherein the liquid hydrocarbons condensed from the second effluent stream comprise less than 10 weight percent of the heavy hydrocarbons provided in the feed mixture to the reaction zone.
- [c7] The method of claim 1, further comprising preheating the feed mixture to the reaction zone.
- [c8] The method of claim 7, wherein the feed mixture is pre-

heated to a temperature from 260° to 399°C (500° to 750°F).

- [c9] The method of claim 7, wherein a hydrocarbon feedstock stream comprising the heavy hydrocarbons and a solvent stream comprising solvating hydrocarbons are separately preheated and mixed to form the feed mixture to the reaction zone.
- [c10] The method of claim 1, wherein heavy metals in the feedstock are deposited on the particulate solids.
- [c11] The method of claim 4, wherein the regeneration of the circulating hot particulate solids comprises combustion of the coke in the regeneration zone in the presence of an oxygen containing gas.
- [c12] The method of claim 11, wherein the hot particulate solids recirculated to the reaction zone have a particle size distribution substantially between 25 and 350 microns.
- [c13] The method of claim 11, wherein the circulating hot particulate solids are fluidized in the reaction and regeneration zones.
- [c14] The method of claim 11, wherein the circulating hot particulate solids are maintained in a transport hydrody-

namic regime in the reaction and regeneration zones.

- [c15] The method of claim 11, wherein the circulating hot particulate solids comprise refractory oxides.
- [c16] The method of claim 15, wherein the refractory oxides are selected from SiO₂, Al₂O₃, AlPO₄, TiO₂, ZrO₂, Cr₂O₃, and mixtures thereof.
- [c17] The method of claim 11, wherein the regeneration is at a temperature from 600° to 1300°C (1112° to 2372°F) and a pressure within about 0.5 MPa (73 psi) of the pressure in the reaction zone.
- [c18] The method of claim 11, wherein the particulate solids are retained in the regeneration zone for a period of less than 60 seconds.
- [c19] The method of claim 1, wherein the solids are cyclonically separated from the first effluent stream.
- [c20] The method of claim 11, further comprising withdrawing a portion of the regenerated solids and replacing with fresh particulate solids to maintain a solids inventory.
- [c21] The method of claim 1, further comprising recovering solvating hydrocarbons from the second effluent and recycling the solvating hydrocarbons in the feed mixture to the reaction zone.

- [c22] The method of claim 1, wherein the weight ratio of solvating hydrocarbons to heavy hydrocarbons in the feed mixture is from 2:1 to 10:1.
- [c23] The method of claim 1, wherein the solvating hydrocarbons include hydrocarbons produced *in situ* during conversion of the heavy hydrocarbons, recovered from the second effluent stream, and recycled to the reaction zone.
- [c24] The method of claim 1, wherein the solvating hydrocarbons in the feed mixture comprise light naphtha.
- [c25] The method of claim 1, wherein the solvating hydrocarbons in the feed mixture comprise heavy naphtha.
- [c26] The method of claim 1, wherein the solvating hydrocarbons in the feed mixture comprise distillates.
- [c27] The method of claim 1, wherein the solvating hydrocarbons in the feed mixture comprise gas oils.
- [c28] The method of claim 1, wherein the feed mixture is contacted with the particulate solids in the reaction zone for a period of between 10 and 30 seconds.
- [c29] The method of claim 1, wherein the temperature in the reaction zone is maintained at between 371° and 593°C

(700° and 1100°F).

- [c30] The method of claim 1, wherein the temperature in the reaction zone is maintained at between 454° and 538°C (850° and 1000°F).
- [c31] The method of claim 1, wherein a fluid phase of the reaction mixture in the reaction zone is maintained in a single phase.
- [c32] The method of claim 1, wherein a fluid phase of the reaction mixture in the reaction zone is maintained at a temperature and pressure outside a retrograde regime of the fluid phase.
- [c33] The method of claim 1, further comprising the steps of:
 - (E) hydroprocessing the second effluent stream from
 - (D) in the presence of hydrogen and a hydroprocessing catalyst in a hydroprocessing zone at temperatures and pressures sufficient to maintain a single fluid phase in the hydroprocessing zone to produce a hydroprocessed effluent stream;
 - (F) recovering the hydroprocessed second effluent stream from the hydroprocessing zone; and
 - (G) separating solvating hydrocarbons and at least one product stream from the hydroprocessed effluent stream.

- [c34] The method of claim 33, wherein the hydrogen is present in situ in the second effluent stream.
- [c35] The method of claim 33, further comprising adding a hydrogen-rich gas stream to the second effluent stream upstream from the hydroprocessing zone.
- [c36] The method of claim 2, wherein the separation in (E) further comprises:
 - (a) hydroprocessing at least a portion of the third effluent stream in the presence of hydrogen and a hydroprocessing catalyst in a hydroprocessing zone at temperatures and pressures sufficient to maintain a single fluid phase in the hydroprocessing zone to produce a hydroprocessed effluent stream;
 - (b) recovering the hydroprocessed effluent stream from the hydroprocessing zone; and
 - (c) separating solvent from the hydroprocessed effluent stream recovered from (b)
- [c37] The method of claim 36, wherein the hydrogen is present in situ in the third effluent stream.
- [c38] The method of claim 36, further comprising adding a hydrogen-rich gas stream to the third effluent stream.
- [c39] A method for the production of fuels, petrochemical

feedstocks and olefins, comprising:

- (A) providing a feed mixture of heavy hydrocarbons having normal boiling points above 538°C (1000°F) and solvating hydrocarbons comprising normal boiling points below 538°C (1000°F) at a ratio of the solvating hydrocarbons to heavy hydrocarbons of at least 2:1;
- (B) introducing the feed mixture into a reaction zone containing hot particulate solids to form a reaction mixture;
- (C) maintaining the reaction mixture in the reaction zone at a temperature and pressure above critical temperature and pressure of the feed mixture for a period of 60 seconds or less to deposit coke onto the solids and produce a first effluent stream comprising a suspension of the particulate solids in a mixture of solvating hydrocarbons, including converted hydrocarbons, having normal boiling points below 538°C (1000°F);
- (D) separating particulate solids from the first effluent stream to produce a solids-lean second effluent stream;
- (E) treating at least a fraction of the solids-lean second effluent by catalytic reforming, catalytic cracking, hydrotreating, hydroprocessing, or a combination thereof, to produce lower molecular weight hy-

drocarbons; and

(f) separating or blending the lower molecular weight hydrocarbons to obtain at least one product selected from the group consisting of motor fuels, olefins, petrochemical feedstocks and combinations thereof.